COLLECTED PAPERS

OF

Oliver Cummings Farrington, Ph.D.

Volume I
(1899-1901)

Contents

1899	A Fossil Egg from South Dakota	1
1901	Observations on Indiana Caves	2

UM

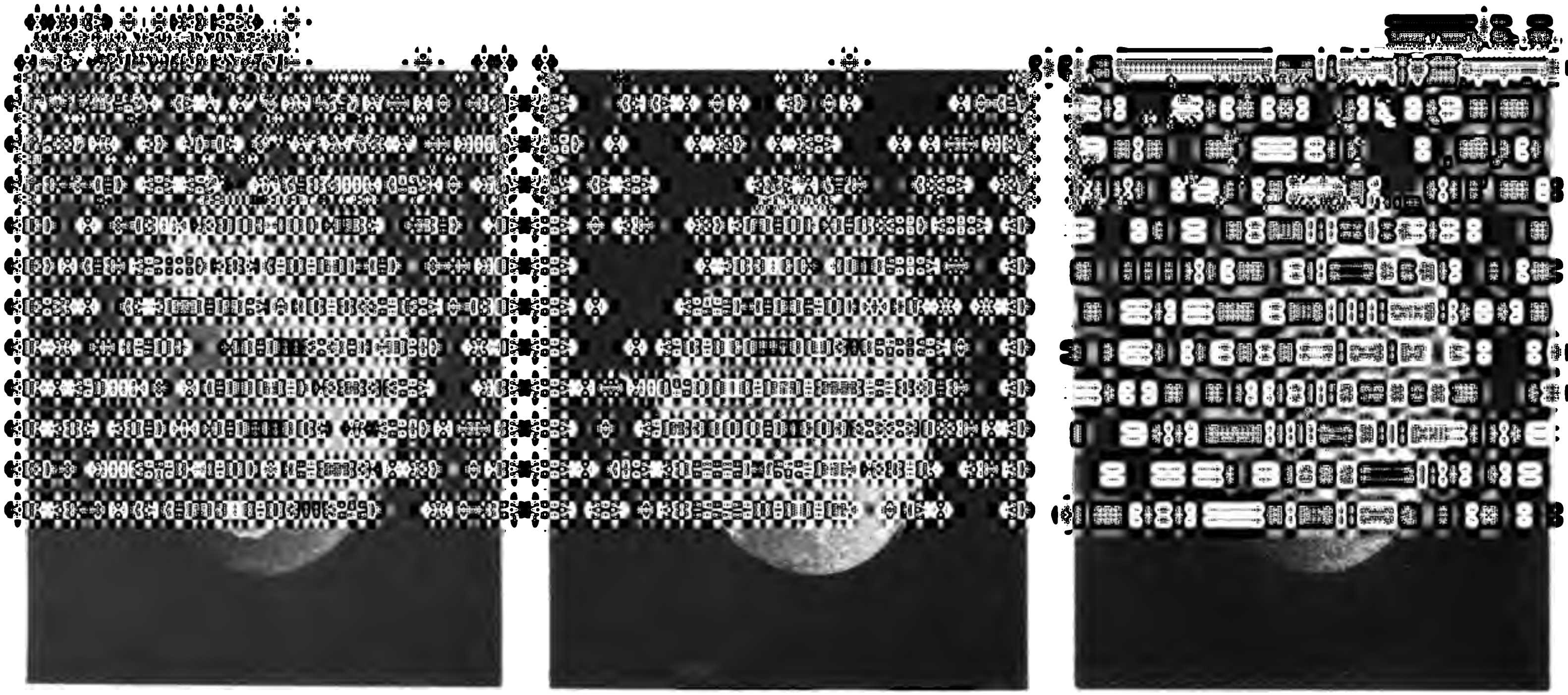
Vol. I, No. 5.

FROM

TA

N, Ph.D.,

ogy.

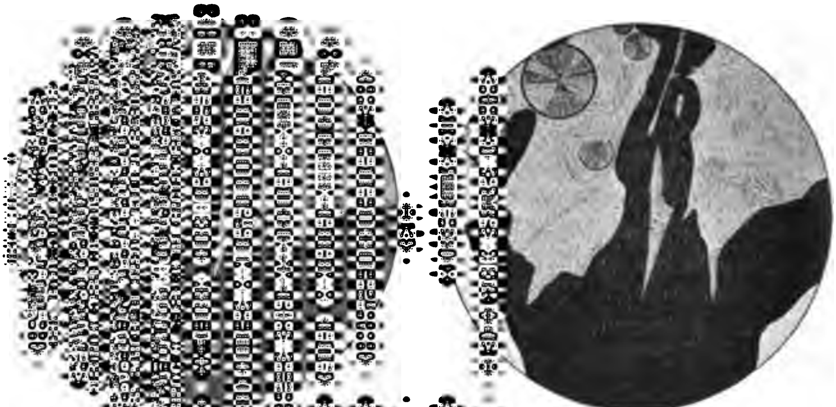


[FROM PHOTOGRAPHS BY H. W. MENKE.]

FOSSIL EGG IN THREE DIFFERENT POSITIONS, SHOWING FORM AND STRUCTURE.

[NATURAL SIZE.]

[illegible] g of the spherules remains [illegible] opal. The interior portion [illegible] quartz. This is similar to [illegible] the interior of some of the [illegible] The spherulitic interference [illegible] e optical character is nega- [illegible] not be regarded as similar [illegible] s oolite, but is probably a [illegible] nce with which any foreign [illegible] The main portion of the [illegible] s structure



[illegible] CIDA.]

[illegible] . 2. Same in polarized light. The [illegible] becomes black; the chalcedony shows a [illegible] fibrous structure and the spherules interfer- [illegible] crosses.

X22.

[illegible] ns of the region, studied for [illegible] arked fibrous character and [illegible]

[illegible] as a whole was found to be [illegible]

[illegible] to obtain an explanation of [illegible] petrifaction could occur, if [illegible] find any account of a simi- [illegible] fore. The fossil Chelonian [illegible] nce, are simply shells filled [illegible] the New Zealand birds are

likewise only shells, which have been preserved by reason of their thickness. Neither of these occurrences are, therefore, cases of true petrifaction. At first thought, an egg of the sort here described may seem too perishable for preservation by a process of true petrifaction. It is difficult to understand how, in such a mass as an egg, petrifying liquids could pass to and fro, removing particles of organic matter and replacing them by particles of silica, in the way that it is generally understood that petrifactions usually take place. On further consideration, however, the natural petrifaction of an egg need not seem to be an impossible phenomenon. If covered as soon as deposited, by mud or earth, as it is likely to have been in this region, its substance might endure for months or years. Or, the process of petrifaction might have begun at once, since the present chalcedony veins of the region show that circulating siliceous waters are abundant there.

Given conditions of this sort, I believe that petrifaction could have gone on by a process of endosmose and exosmose similar to that believed by M. Forster Heddle* to produce the formation of agates. As the cases seem so similar in their conditions, his theory may be quoted in full: "We have now a cavity slightly lined with chalcedonic matter, containing, within, water more or less pure, while without (that is, outside the now double skin, delessite and first layer), we have a strong solution of colloidal silica constantly supplied. Endosmose and exosmose are set up with resistless force. The *strong* solution finds its way through the two or any number of increasing skins; the *weak* water is forced out through the point of infiltration, and so in its passage out thins all the successively deposited layers at that place. By the continuous flow of colloidal silica (held in solution by liquid) through the already coagulated or deposited layers, continuous coagulation of the silica in the yet hollow agate, and continuous extrusion of the residual water, we have the ultimate filling up of the cavity, and a solid agate formed." The parallelism of conditions in the two cases is so apparent as to need no emphasis. The shell of the egg and its lining membrane furnish the "skin," the albuminous or watery substance within the egg the weak solution, and the circulating siliceous waters known to abound in the region the strong solution of colloidal silica. Or the positions of the latter may have been reversed, the thicker liquid having been within and the thinner without. In either case a transference would take place. While I cannot say that Professor Heddle's theory, that agates have been formed in this way, is altogether the adopted one, the stages of

* Nature, Vol. XXIX, p. 419.

the process as he describes them at least seem logical and reasonable, and may well have brought about petrifaction in the case of an egg. Of course it is not held as proved that, in the specimen under consideration, those portions which I have designated as white and yolk have been preserved in their original structure and proportions. While this may be the case, it is again quite as likely that the portion which I have designated as the yolk represents the shrunken residue of the egg substance as a whole. Its appearance, indeed, rather indicates this, since the curved plates that have been described resemble shrunken membranes. The remainder of the interior may then have been filled simply with water at the time petrifaction set in.

It is more difficult to explain the fact that most of the "yolk" is composed of opal while the rest of the interior is made up of chalcedony. The difference is, however, not essentially greater than that often found to exist in different layers of agates.

For establishing any conclusions as to the nature of the parent of the egg, no other data are available than its form. For a knowledge of what this indicated I referred to Mr. Wm. A. Bryan of the Museum, who has very kindly furnished the following report: "The form of the specimen suggested to me on the first examination that it was that of an egg of one of the Anatidæ or Duck family. Further study confirmed this conclusion, the similarity in form to that of eggs of Anatine birds being marked and such as to distinguish it from the eggs of birds of other families. Measurements of the fossil egg, too, showed it to have the same proportions as those of members of the Anatidæ, while they differed to a marked degree from those of other families. These similarities and differences are illustrated in the eggs shown in Pl. XXI. The eggs there shown were selected to represent as nearly as possible types having the general oölogical characters of the different families of birds whose eggs might resemble the fossil form, or whose habits would lead them to deposit eggs under conditions favorable for petrifaction. To complete the form of the fossil egg for this purpose, the outline on the broken end was filled out with plaster. By this method the form of the egg was reproduced, any error being probably within $\frac{1}{100}$ of an inch. The measurement of length was therefore made on this completed egg."

"The following table shows the species of eggs chosen and their measurements:"

No.	Order.	Family.	Species.	Common Name.	Measurements. (Eng. inches.)
1	....	....	....	Fossil Egg....	2.03 × 1.49
2	Anseres	Anatidæ......	Anas fulvigula	Florida Duck.	2.05 × 1.52
3	Longipennis..	Laridæ.......	Sterna fuliginosa........	Sooty Tern....	1.84 × 1.28
4	Gallinæ.......	Tetraonidæ...	Tympanuchus americanus.	Prairie Hen ..	1.72 × 1.28
5	Limicolæ.....	Charadiidæ...	Charadrius dominicus.....	American Golden Plover	1.86 × 1.40
6	Herodiones...	Ardeidæ......	Ardea cærulea	Little Blue Heron.....	1.73 × 1.30
7	Pygopodes....	Podicipidæ...	Podilymbus podiceps....	Pied - billed Grebe.....	1.71 × 1.19
8	Steganopodes.	Phalacrocoracidæ.......	Phalacrocorax p. robustus...	Violet Green Cormorant.	2.52 × 1.51

It will be seen that in form and proportional measurements the fossil egg resembles most closely that taken as the type of the Anatidæ. The probability of its parent belonging to that family is also increased when one considers the nature of the formation in which the egg was found. This is of lacustrine origin, and birds of this family are well known to frequent the waters of lakes. Unfortunately, from the manner in which the egg was found, it cannot be stated positively that it came from the beds immediately adjacent. These are of White River age, but as the specimen was not found *in situ* it may of course have come from later and higher beds, or, as has been suggested, be even an egg of a comparatively modern bird. Yet the probabilities are strongly in favor of the supposition that the specimen was, until just before it was found, imbedded in the formation immediately adjacent, and was brought to light by erosion, just as bones of extinct vertebrates are continually being exposed in the same region at the present time. If these suppositions are correct, the specimen affords evidence of the existence of birds of the order Anatidæ in Early Miocene times.

The only other mention of the finding of bird remains in rocks of this period, in this country, of which I am aware, is that of two species of birds from the Amyzon shales of Nevada. These remains consist of scattered bones and feathers, and represent birds

one species of which has been described by J. A. Allen* as a passerine bird of the family Fringillidæ, the other by E. D. Cope† as a species of the order Grallæ and tribe Limicolæ.

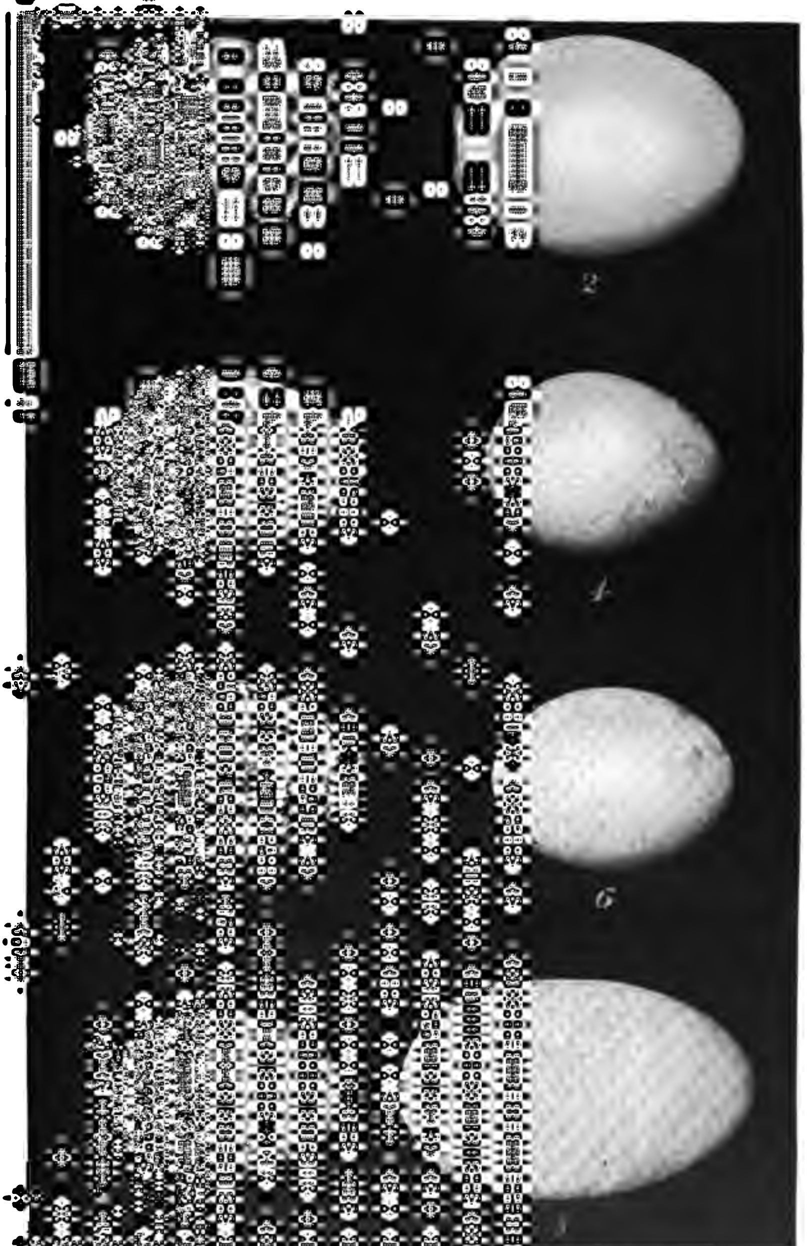
In conclusion, the hope may be expressed that if any specimens of similar character are known they will be fully described, so that more evidence may be at hand to clear up the difficulties encountered in the study of this one. I have reports of the finding of at least two other petrified eggs at different times in the same region, but have been quite unable to verify the reports or see the specimens. A systematic study of the forms of eggs seems also desirable, so that in the future definite conclusions may be drawn regarding the order or family to which a parent belonged when an egg is the only relic of the parent to be obtained.

* Bull. U. S. Geol. Surv. Terrs., IV, 1878, p. 443, Pl. I.

† Rept. U. S. Geol. Surv. Terrs., Vol. III, Book I, p. 754, Pl. LIX.

PL. XXI. FOSSIL EGG AND EGGS RESEMBLING IT IN FORM OR PROBABLE HABITAT OF PARENT.

Fig. 1. Fossil Egg.
Fig. 2. Egg of *Anas fulvigula.* Florida Duck.
Fig. 3. Egg of *Sterna fuliginosa.* Sooty Tern.
Fig. 4. Egg of *Tympanuchus americanus.* Prairie Hen.
Fig. 5. Egg of *Charadrius dominicus.* American Golden Plover.
Fig. 6. Egg of *Ardea cœrulea.* Little Blue Heron.
Fig. 7. Egg of *Podilymbus podiceps.* Pied-billed Grebe.
Fig. 8. Egg of *Phalacrocorax p. robustus.* Violet Green Cormorant.



[illegible] Probable Habitat of Parent.

SEUM

Vol. I, No. 8.

INDIANA

Ph.D.,

eology.

VOL. I, NO. 8.

[illegible] INDIANA

Ph.D.,

TABLE OF CONTENTS.

	Page
Observations on Indiana Caves,	247
Wyandotte Cave,	247
Marengo Cave,	256
Shiloh Cave,	262
Coan's Cave,	264

OBSERVATIONS ON INDIANA CAVES.

A visit of the writer to several caves in Indiana during the months of August and September, 1900, afforded an opportunity for a number of observations which seem to be new or confirmatory of observations previously published by others. The caves visited were Wyandotte Cave, Crawford County; Marengo Cave, Crawford County; Shiloh Cave, Lawrence County; and Coan's Cave, Monroe County, all in the State of Indiana. Detailed descriptions of all these caves have been given in several reports of the Geological Survey of Indiana, the latest and most complete being in the twenty-first annual report, 1896, by W. S. Blatchley. There is also given in that report a bibliography of the caves and their fauna.

WYANDOTTE CAVE.

CIRCULAR OR DOME-SHAPED HALLS.—The hall known as "Helen's Dome" has to a marked degree the form of a hollow cylinder standing vertically. "Rothrock's Cathedral" has the form of a huge dome roofing a short cylinder, the center of the dome being in turn cut by a cylinder rising above it. The "Senate Chamber" has a similar form except that its shape is elliptical rather than circular. "Odd Fellows' Hall," "Milroy's Temple," the "Hall of Representatives," and others are likewise dome-shaped. The hall known as "The Rotunda" in Mammoth Cave has also the form of a dome roofing a short cylinder. The dimensions of some of the halls as given by Blatchley* are as follows: Helen's Dome, 80 feet high and 20 feet in diameter; Rothrock's Cathedral, 185 feet high and 200 feet in diameter; the Senate Chamber, 60 feet high with elliptical axes 144 feet and 56 feet in length. The circular or elliptical contour of the walls of these halls and the persistence with which it is maintained throughout successive downfalls of rock is remarkable and indicates that some cause additional to ordinary water erosion must be sought.

**Op. cit.*

Water flowing down vertical joint planes usually produces pits with walls of angular contour, of which the "Bottomless Pit" in Mammoth Cave may serve as a type. It is possible that the circular contours may arise from a solvent action added in an unusual degree to the erosive action of water. By this means the solid angles of the limestone blocks formed by the junction of several vertical with one horizontal joint plane might be dissolved away until a dome-shaped cavity was formed, or the form may be due to a concretionary structure of the limestone like that recently noted in Idaho.* The consecutive removal of the centers of successive domes would cause each to fall in turn, maintaining the dome-like shape. Stream erosion on the floor of such halls may remove this rocky debris as fast as it falls as has been the case at Helen's Dome, or the rise of the conical pile of rocky debris (such as that known as "Monument Mountain" in Rothrock's Cathedral), may nearly keep pace with the fall of the domes above. It is evident that if this process of caving in is continued until the surface is reached, "cistern-like pits leading down into the bowels of the earth" will be seen from above. Such is the description given by W. H. Holmes† of the cenotes or sacred wells seen in Yucatan, some of which are so round and even-walled as to be taken for works of art. They are often, Holmes states, 100 feet or more in depth and 200 or 300 feet in diameter. It seems evident from what has been stated above that human agencies need not be appealed to for the formation of such wells.

FISSURE SYSTEMS.—Systems of fissures forming rectangles or parallelograms closely resembling those produced by Daubrée's well-known experiment illustrating the formation of joints by torsion are to be seen at many places along the roof of the cave. As an exhibition of jointed structure on a horizontal plane they are very satisfactory. Often a secondary system of fissures appears in conjunction with the primary one. In many places, such as the "Pillared Palace," the formation of stalactites and stalagmites has taken place along the lines of the joint planes. The stalactites and stalagmites extend, therefore, in straight lines in most cases directly beneath the crevice made by the joint plane.

DISTRIBUTION OF BATS.—Bats were found in all parts of the cave which I entered, even in the so-called "Unexplored Regions," the entrance to which is a passage averaging about one foot in height for a distance of 60 feet. If the bats were especially numerous anywhere, it was in the hall known as the "Senate Chamber," which,

*A curious mineral formation in Idaho Engineering and Mining Journal, March 2, 1901.

†Field Columbian Museum Publication 8, p. 19.

according to Blatchley's measurements, is one and one-sixth miles from the entrance to the cave. I may also remark that I noticed a similar wideness of distribution of the bats in Coan's Cave, though that is only one-eighth of a mile in length. These observations seem to contradict the statement of Mr. William H. Hess,* that "bats as a rule go but a short distance from the entrance," and throw doubt on any theory of the origin of nitrates in cave earths which rests on the assumption that bats do not inhabit the more remote portions of caves.

VERMIFORM STALACTITES.—The vermiform stalactites which are to be seen in many places in this cave have attracted the attention of many observers and brought forth many theories as to their origin. These theories are admirably summed up and the subject ably treated in the paper by Merrill "On the formation of stalactites and gypsum incrustations in caves."† My observations lead me substantially to agree with Merrill's conclusion that the vermiform character of stalactites of this cave is due to the fact that the drops of water making them have been guided to other positions than those dictated by gravity by the directions assumed by spicules of calcite in crystallizing. It appears to me, however, that the carbonate of lime producing this effect must be in a condition differing somewhat from the ordinary pulverulent form in which it appears at the end of the usual stalactite tube, or in other words, that some additional conditions must be appealed to in order to lead to the formation of stalactites of this sort.

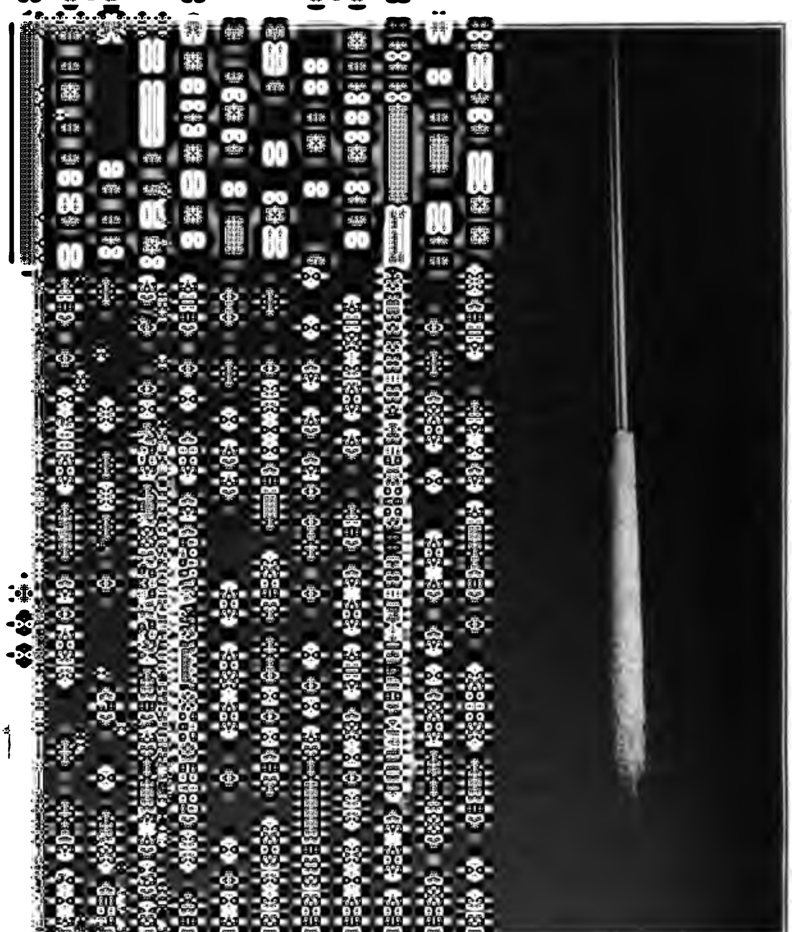
The resemblance of the stalactites to the well-known forms of aragonite denominated *flos ferri* is quite striking, and perhaps of some significance. Senft‡ reached the conclusion that the *flos ferri* forms of aragonite were produced from very dilute solutions of carbonate of lime, which, owing to protection from changes of air and temperature, evaporated very slowly. Calling attention to the form of the spicules of aragonite he deduced much the same theory for the origin of the *flos ferri* forms as that suggested by Merrill for the Wyandotte Cave vermiform stalactites. It is characteristic of aragonite, however, to crystallize in slender needles, but not so of calcite. Tests which I have made of the specific gravity of the substance of the Wyandotte vermiform stalactites indicates that it is, as

*Journal of Geology, Vol. 8, No. 2.

†Proc. U. S. Nat. Mus., Vol. XVII, pp. 77–81.

‡Die Wanderungen und Wandelungen des kohlensaures Kalkes, Zeitschrift der Deutsche Geologische Gesellschaft, Vol. XIII, p. 269.

[illegible] he exact stages of the proc-
[illegible] calcite would be produced
[illegible] are those by which such
[illegible] until we have better knowl-
[illegible] to suppose that the same



[illegible] talactite, a glass rod and a glass tube.

[illegible] aragonite (supposing Senft
[illegible] ions) viz.: deposition from
[illegible] may be regarded as those
[illegible] lcite. Why, however, ara-
[illegible] nd calcite in the other, I can-

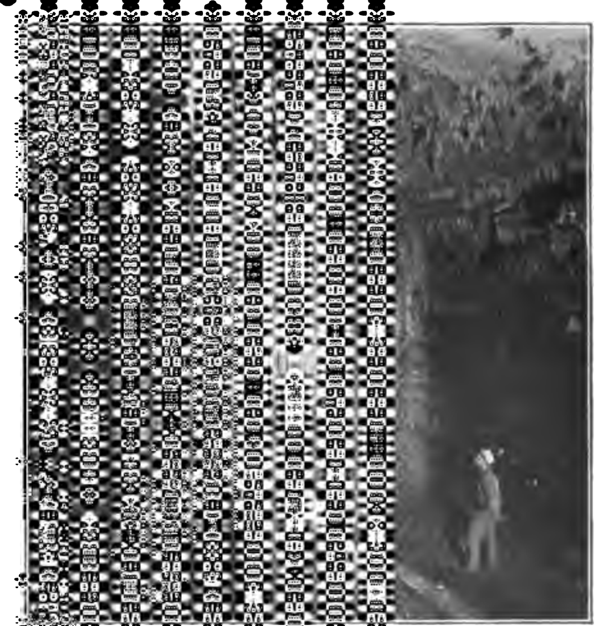
...te's* experiments led ... causes the formation ... ion which Senft has

....—The force of capil-... the vermiform stalac-... forms of stalactites in ... seem to have been ... sition from this cause ... herto been supposed. ... y determined experi-... from solutions would ... ave used solutions of

...—Stalactite, Marengo Cave, ...owing form probably influenced ... capillary deposit. ... nat. size. (Mus. No. G. 963.)

[illegible] r current trickling down [illegible] the drop of water at the [illegible] water at the end of a stalac- [illegible] recommended often to be [illegible] andle for a moment close [illegible] s left in the water will be [illegible] longer than any convection [illegible] andle would account for. [illegible] hich I watched for a period [illegible] t up. The deposit formed [illegible] nent with salt may be con- [illegible] id evaporation from a con- [illegible] y admits of much further [illegible] rmining what variations, if [illegible] amount of the deposit by [illegible], by varying if possible the [illegible] rent salts.

[illegible] —Fig. 3. The shape and [illegible] n described. It is located [illegible] ber," which is accurately



[illegible]" Wyandotte Cave.

described by Collett* as "a vast elliptical amphitheatre * * * The sides are built up with massive ledges of limestone, thinning and converging upward into a monster dome with a flat elliptical crown 50x20 feet in diameter. The center of this vast room is piled up with a great mass of rocky debris fallen from the immense cavity above." Blatchley† gives the exact measurements of the hall, so far as its length and breadth are concerned, as 144 feet and 56 feet respectively. He gives further the following graphic description of the Pillar: "The mass of fallen rock in the center, known as 'Capitol Hill,' is about 32 feet in height, and is crowned to a depth of several feet with an immense mass of stalagmitic material. From the center of this mass rises from the top of the hill the grandest natural wonder in Wyandotte Cave—the great fluted column of satin spar or crystalline carbonate of lime known as the 'Pillar of the Constitution.' Perfectly cylindrical, 71 feet in circumference, and extending from the crest of the hill to the ceiling above, this enormous column exceeds in magnitude any similar formation in any known cave on earth." No statement of the height of the Pillar is given by this author. Collett states that the Pillar is about 35 feet high, and Mr. H. A. Rothrock, the present manager of the cave, informs me that this is undoubtedly correct, so far as the southern side of the Pillar is concerned. Owing to the fact that the stalagmite is situated a little to one side of the apex of the cone of debris, the deposit has formed about ten feet farther down on the southern side than on the northern. On the northern side, therefore, the height is about 25 feet. The mean of these, or 30 feet, may be taken as the height above the debris as a whole. The intimate structure of the mass as shown by examining fragments taken from the pit artificially excavated at its base is distinctly banded or onyx-like. The individual bands are so narrow as to be scarcely distinguishable with the naked eye, but these are grouped into series of larger bands, 0.5 mm. to 5 mm. in thickness, which differ in color or in structure so as to be plainly distinguished from one another. A secondary fibrous structure in which the fibres are at right angles to the plane of deposition has been developed through most of the bands. The latter lie for the most part nearly horizontal, but occasionally are highly contorted. The only statement I can find as to the mineralogical nature of the substance of the Pillar is that of Blatchley, who refers to it as made up of "satin spar, the purest form of carbonate of lime." Having examined somewhat carefully the substance of several hand speci-

*Indiana Geol. Survey, 1878, p. 473.

†*Op. cit.*, p. 156.

mens which I took from the Pillar I find them to be made up chiefly of aragonite. Not only is the specific gravity that of aragonite (2.92) as obtained by Thoulet's solution, but several cavities show the typical radiating bladed crystals of this form of carbonate of lime. The occurrence, therefore, furnishes an exception to the rule noted by Merrill* that the onyx marbles are generally calcite. Between the distinctly fibrous layers of some portions are interposed other layers microgranular and non-fibrous in structure. The substance of these I found to be of lower specific gravity than that of the fibrous layers. It is in other words, calcite. Here, then, are variations from aragonite to calcite taking place in the growth of a single mass representing corresponding variations in the circumstances of its growth. A similar occurrence is noted by Senft† in a deposit near Eisenach, Germany. It is unfortunate that our present knowledge of the conditions bringing about the formation of these two salts is so inadequate that we cannot know exactly what changes are indicated by such alternations.

AGE OF THE PILLAR.—The immensity of this stalagmite, and the certainty that it has been formed by a fairly uniform process of deposition, lead almost irresistibly to an inquiry as to whether any satisfactory estimate of the length of time required for the formation of the mass can be made. Some attempts seem to have been made to determine the rate of deposition by measuring the thickness of the film formed upon glass vessels left in the water now dripping at the Pillar. Unfortunately these measurements are not very accurate. Collett states on one page of his report (p. 467) that water dripping "at the 'Pillar of the Constitution' has deposited a film of less than one-fiftieth of an inch during five years, or at the rate of one inch in 250 years," while on another page (p. 474) he states that "an estimate based on quasi observations places the rate of this stalagmitic growth at one inch in 100 to 150 years." Hovey, in his "Celebrated American Caverns" (p. 138), speaks of the Pillar as growing ten inches in 1,000 years, though he gives no data on which to base the statement. Mr. Rothrock, the present proprietor of the cave, has at my request had a new vessel placed in the water since my visit and it is hoped that this may furnish a means of accurate measurement in a few years. For the present, however, taking Collett's lower rate of one inch in 250 years

*The Onyx Marbles: their origin, composition, etc., Rep. U. S. Nat. Mus., 1893, p. 553.
†*Op. cit.*, p. 289.

as probably the nearest correct, it can be easily calculated that 90,000 years would have been required for the Pillar to rise to its present height had the flow of water during all this time been uniform over the constantly increasing surface. I believe it safe to regard this as a minimum age for the Pillar, though I am well aware that owing to various factors which may give rise to fluctuations of growth, geologists are accustomed to believe that no satisfactory time values can be assigned to measurements of stalagmitic deposits. See Dana's Manual of Geology, 4th edition, p. 1024. But may not these fluctuations be confined within limits as narrow as those affecting other measurements of time, such as the rate of recession of gorges or the rate of sedimentation, especially when we remember that variations in the rate of deposit almost certainly find expression in the form of the stalagmite? The stalagmite under discussion certainly has a remarkably symmetrical form. I believe, therefore, that it must have grown at a fairly uniform rate.

Regarding the possibilities of arriving at any satisfactory value of the mean age of the Pillar, I have no very lively hope of success. It is hardly likely that the flow of calcareous waters over the entire mass of the Pillar was constant throughout the period of its growth. At the present time, growth is hardly taking place over one one-hundredth part of the surface, yet a mean value can be assigned to this factor only in a purely arbitrary way with nothing to guide the judgment that I can think of. The data for assigning an age value to the large stalagmite now in the Museum of Science and Art, Edinburgh, seem to me better founded. This stalagmite is 11 feet long and 28 inches in diameter. It was sawed from its base in a cave in Bermuda in 1819. In 1863, Sir Alexander Milne in visiting the cave measured the amount of matter formed on the base since the removal of the stalagmite and found it to be five cubic inches. At that rate it can be easily calculated that about 600,000 years were required for the formation of the stalagmite.* Numerous considerations show that it would be incorrect to apply this ratio to the formation of the 20,000,000 cubic inches of matter which make up the Pillar of the Constitution, and I introduce the illustration only to show that a much greater age should probably be assigned the Pillar than that which I have given as a minimum. In addition to the time consumed in the growth of the Pillar, a large previous period was required for the erosion of the chamber in which it stands.

*My data are from the Museum label. I think the facts have been published, but I cannot give the reference.

Data are meagre for estimating the length of this period. Prestwich* has estimated the rate of erosion by the Thames as one inch in 1,000 years. The chalky Cretaceous and Oölitic strata over which the Thames flows are doubtless eroded at a more rapid rate than the compact limestone in which Wyandotte cave is situated. Taking this rate, however, as a minimum, it will be found that a period of 360,000 years would be required to erode the "Senate Chamber" to the depth of the base of the stalagmite.

MARENGO CAVE.

THE CAVE FLOOR TERRACE.—The greater portion of the floor of this main cave shows a well marked terrace recording two distinct stages in the life of the stream which before its final disappearance flowed through the cave. Of these two stages the stream of the older stage had a width of from 15 to 20 feet and a current of sufficient velocity to make large ripple marks on its bed of coarse alluvium. These ripple marks are symmetrical and their long slope is plainly away from the present entrance to the cave. This, therefore, was the direction of flow of the stream. In its second stage the stream was reduced to a width of about 10 feet and its current was more sluggish. It cut a trench of the above width with nearly vertical walls to a depth of about two feet in the bed of the old stream, but did not have a current of sufficient velocity to produce ripple marks on its bed. A further greater sluggishness as compared with the first stream is indicated by the somewhat winding course which it took through the bed of the latter. The disappearance of this stream must have taken place somewhat suddenly, for there has been no trenching of its bed nor sloping of its banks such as would have occurred if the flow of water had diminished gradually. The bed, now quite dry, has a slightly concave form. A draining away of the stream by the opening of new conduits at a lower level seems the most natural explanation of its two stages and final disappearance. It is of course not impossible that these stages mark a diminution in rainfall or supply of waters from above, but there is on the whole little reason to suspect such abrupt changes in these conditions. It is not unlikely that the large spring situated a few rods west of the present entrance represents the present point of issue of the stream.

*Geology, vol. 1, p. 107.

STREAM DEPOSIT.—Gradual diminution in rate of flow is well shown in the deposit left by a stream tributary to the main stream to be seen at the point called the "Sand Pit" between the "Rock of Gibraltar" and "Fortress Monroe." The stream had a course nearly at right angles to that flowing through the main cave, although its course, as its channel is filled nearly to the roof, can not be followed backward except by digging. Where this tributary emptied into the main stream it formed a delta deposit about eight feet in depth. The main stream in cutting downward has cut through this delta so as to expose a complete section. The deposit is well stratified. There are slight variations in the coarseness of adjacent strata throughout the deposit, but the most striking feature is the obvious gradation from coarse pebbles at the bottom to fine alluvium at the top. The pebbles at the bottom are well rounded sandstone pebbles having about the size of English walnuts. Only a stream of considerable swiftness and volume could have transported them. From such a velocity of current the stream diminished until it bore only the finest alluvium in its latest stages. What could have led to such a diminution in its rate of flow is not apparent, but it is evident that waters flowing through limestone are liable at any time and to any extent to be drawn off in new directions by the opening of new conduits.

ABUNDANCE OF STALAGMITES.—A remarkable feature of the portions of the cave known as "Cave Hill Cemetery" and the "Prison Cell" is the relative abundance of stalagmites. Many of the stalagmites have no corresponding stalactites at all. There can be little doubt that the principles enunciated by Senft* provide adequate explanation of the origin of such results. Senft showed that when the flow of water through a crevice was too rapid, either on account of the verticality of the crevice or the abundance of the water supply, to allow of evaporation and consequent deposition sufficient to form a stalactite, a stalagmite might yet be built up because of the greater opportunity for evaporation given for water falling upon the cave floor. He supported this conclusion by calling attention to the fact that stalagmitic icicles form during the hours of the day when melting is most speedy. These suggestions seem to furnish sufficient explanation for the facts referred to.

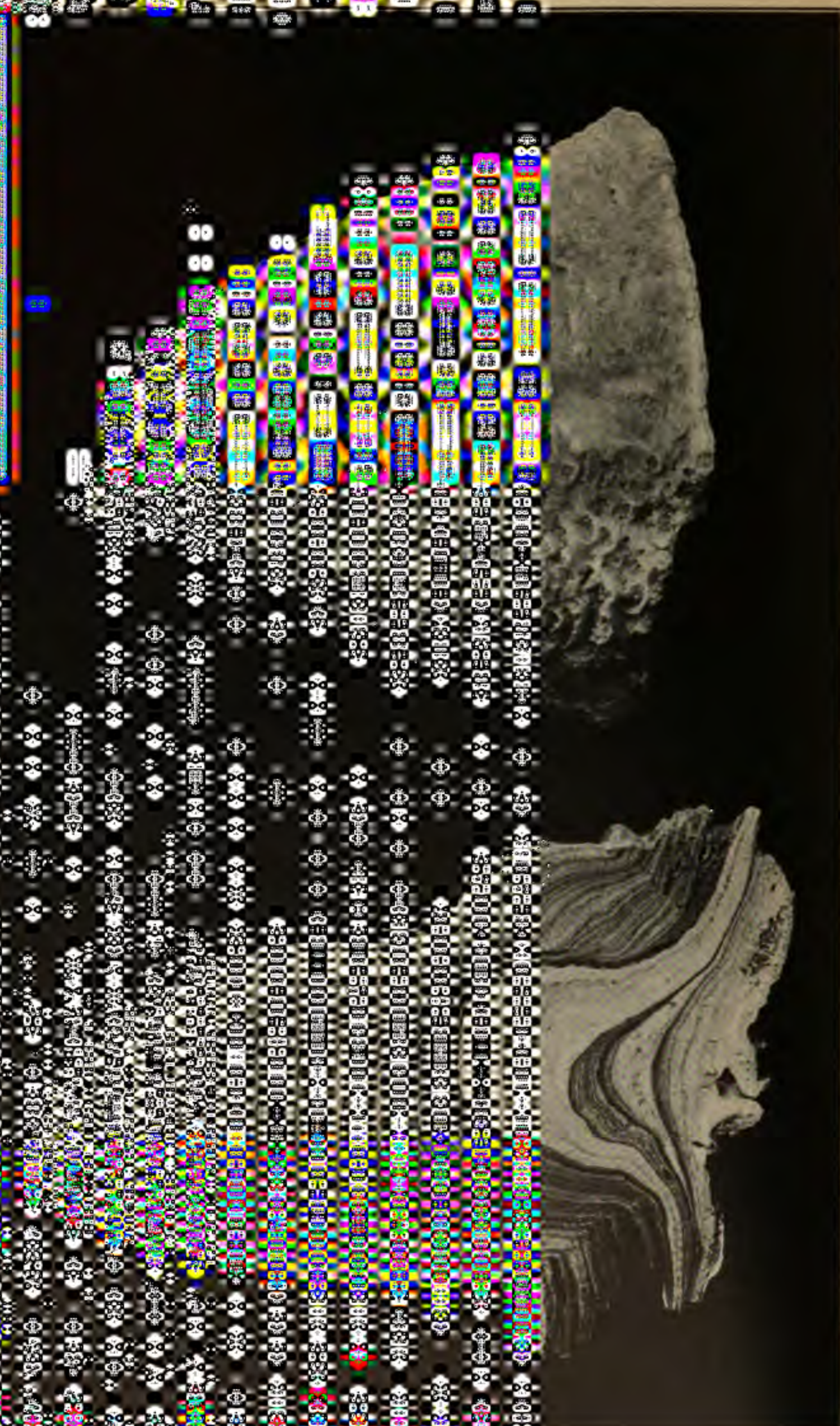
ORIGIN OF PECULIAR FORMS OF STALAGMITES.—The form of many of the stalagmites is remarkable and, so far as I know, peculiar to this

* *Op. cit.*, p. 287.

[illegible] of which the stalagmite
[illegible] g. 4) may serve as a type.
[illegible] be produced by piling a

[illegible] Marengo Cave.

[illegible] truncated, inverted cones
[illegible] ructure appears very regu-
[illegible] e supply of matter in the
[illegible] amination, however, it will
[illegible] are not horizontal, nor do
[illegible] e rather of the nature of
[illegible] Such being the case, it
[illegible] point of dropping of the
[illegible] be sufficient cause for its
[illegible] rowth of a stalagmite are
[illegible] ertson's Cave, Springfield,
[illegible] p to a point about one-third
[illegible] ection to the right. Then
[illegible] ore nearly vertical. Such
[illegible] here no stalactite existed
[illegible] o one place, as is the case



EXPLANATION OF PL. XXXII.

FIG. 1. Section of stalagmite from Robertson Cave, Missouri, showing changes in direction of growth.

(Mus. No. G 604.)

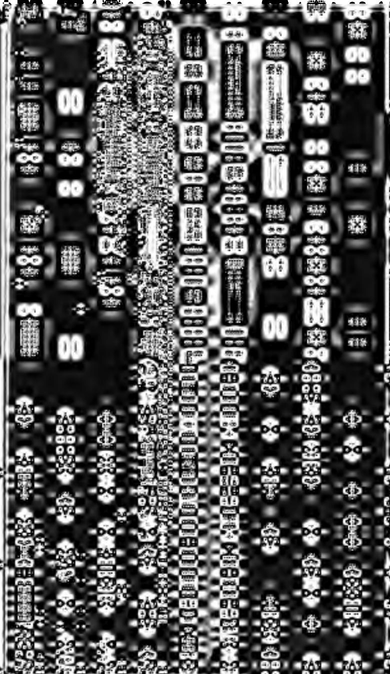
FIG. 2. Cone-shaped stalagmite, Marengo Cave.

(Mus. No. G 1022,)

with those under discussion. If it be considered further that variations in the form of a stalagmite may result from variations in the rate of evaporation and content of carbonate of lime of the water which produces it, further reasons for the peculiarity of form will be added. Thus, if evaporation is rapid, or the content of carbonate of lime high, so that a large quantity of the salt contained in each drop is deposited at the top of the stalagmite and little is left to be relinquished in the subsequent course of the water down the sides, a long, slender stalagmite will be formed. If, on the other hand, evaporation is slow, or the content of carbonate of lime low, so that deposition will take place about equally during the course of the water over the stalagmite, a broadly conical stalagmite will result. It is evident that such variations occurring during the growth of any single stalagmite would find expression in corresponding forms in different parts of the stalagmite.

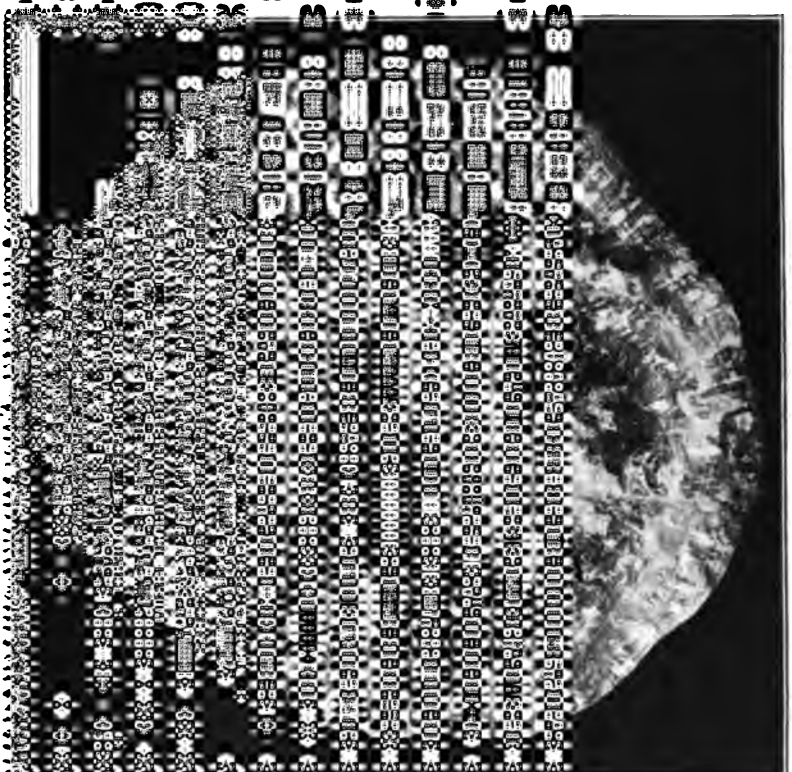
Another form of stalagmite so far as I know peculiar to this cave is that of a flattened cone. Such are the stalagmites known as "Mt. Vesuvius" and the "Diamond Dome." The form is illustrated by Fig. 2, Pl. XXXII, showing a stalagmite collected by the writer at the cave. I have indicated above in what manner slight evaporation as compared with the rate of flow of water or a relatively low content of carbonate of lime might be expected to produce such a form. It may be further noted that the lateral surface of these stalagmites, instead of being smooth like that of the ordinary stalagmite, is built out in a series of sinuous walls running more or less horizontally around the cone. These walls form numbers of little pools usually filled with water and containing delicate crystalline aggregations of carbonate of lime. The low slope of the surface allowing slow movement of the water over it is doubtless responsible for the construction of these walls.

STALAGMO-STALACTITES.—Usually in the growth of cave formations, a stalactite forms above its counter stalagmite. An odd reversal of this condition of things so that the stalagmite forms above the stalactite is to be seen in several instances in this cave, the formation known as the "Mermaid" being perhaps the best example. Such stalagmo-stalactites are formed by a drip taking place on the edge of a limestone shelf so that the water which builds up the stalagmite, in pursuing its further downward course forms a stalactite as well. Of the general appearance of such formations Fig. 5, showing a specimen collected in Shiloh Cave, will give a sufficient idea.



[illegible] S AND STALAGMITES.—The [illegible] talagmites of this cave is [illegible] diating outward from the [illegible]. The fibres pass unin- [illegible] tedly through the concen- [illegible] ings of growth and the [illegible] ure is doubtless, therefore, [illegible] nted out by Merrill,* of [illegible] lary origin. The fibrous [illegible] nce is not, however, [illegible] ite, but calcite. In con- [illegible] o the forms possessing [illegible] tructure are many whose [illegible] nce has a wholly coarsely- [illegible] line structure exhibiting [illegible]-pervading rhombohedral [illegible] ge. Intermediate stages [illegible] en these two extremes can [illegible] een in many cases. Of [illegible] al interest are stalagmites [illegible] ting a structure like that [illegible] in Fig. 6. This figure [illegible] a cross section of a [illegible] mite, the peripheral por- [illegible] of which are fibrous in [illegible] ure while the central are [illegible] bohedral. I am of the [illegible] of proving or disproving [illegible] progressive change in the [illegible] oward a more stable con- [illegible] portion of the stalagmite [illegible] rhombohedral planes, and [illegible] That the rhombohedral [illegible] seems to be indicated by [illegible] the oldest and most meta- [illegible]. G. Elliot has suggested [illegible] ce of the stalagmite may [illegible] out the change to a rhom- [illegible] But whatever the deter- [illegible] instructive illustration of

... bonate of lime was ... The substance then ... s continuous fibres ... ion. Then with the ... ement was made by ... es together grouped ...



... to rhombohedral structure.

... ose this word, com- ... s a general name for ...

... stalactites and stalag- ... ing, is the only one ... in process of forma- ... f their rate of growth ... In the hope of obtain-

ing, in the lapse of years, some data on this point Mr. S. M. Stewart, manager of the cave, kindly allowed, at my request, several stalactites and one stalagmite to be marked by Mr. Claude Stroud, who lives near the cave, and who, by keeping watch of their growth, can note any variations which they undergo. It will be understood, however, that the rate of growth is so slow that it is not likely that before the end of ten years at least any appreciable change will have taken place. The record of the stalactites marked is as follows:

No. 1	Near "Tower of Babel,"	Drops at intervals of	$3\frac{1}{2}$ minutes.
No. 2	In "Queen's Palace,"	" " "	" 45 seconds.
No. 3	" " "	"	216 times per minute.

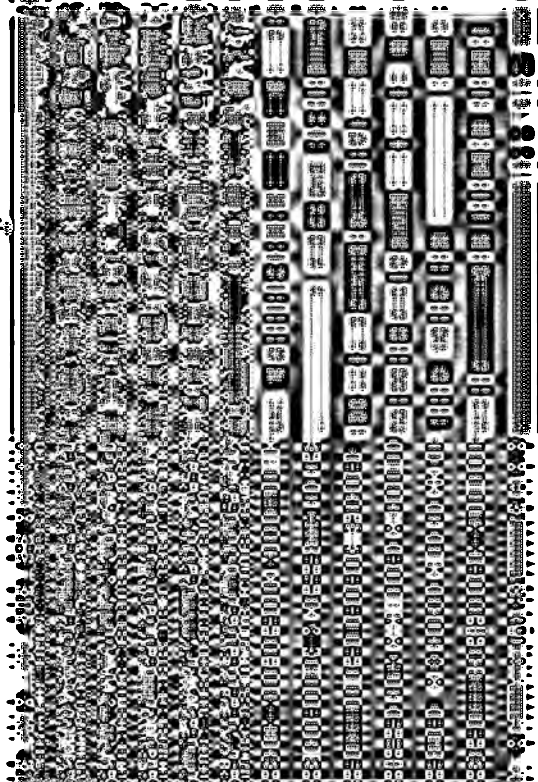
These are simple stalactite tubes.

The stalagmite marked is in "Crystal Palace Gallery," and receives eighteen drops a minute.

SHILOH CAVE.

ERODED STALACTITES.—The stalactite shown in Fig. 7, occurring near the southern end of the cave, furnishes an interesting illustration of the fact that cave waters may vary in their action from formative to erosive, according to the quantity of carbonate of lime they contain. Thus, in the case of the stalactite here represented, the waters flowing over the limestone shelf to which it is attached had at one time built it up to the general form shown. Later, however, the character of the waters changed and they began to erode, as shown by the pits on the surface, the very mass they had previously built up. These processes of deposition and erosion are, of course, going on side by side in nearly all limestone caves, but it is not often that erosion follows so rapidly after deposition. Many smaller stalactites in other parts of the cave show similar erosion.

LEAF STALACTITES.—Many of the stalactites of this cave are leaf-like in their form so far as this may describe a broad, thin and pointed shape. Often the appearance is that of a series of ovate leaves folded along their midribs and hanging down from a projecting ledge. The "leaves" of one such projecting mass are nearly six feet in length, and the weight of the mass must be several thousand pounds. It is remarkable that such a weight can be sustained



t is at right angles to
wall. Observation
the broken end of
y of the "leaves" of
h a group of stalac-
s will show the man-
r of growth. (See
g. 8.) Such growths
not formed by water
ckling down a crevice,
from currents de-
uching over a lime-
ne shelf. The shelf
ist project slightly
d the current of water
ust be relatively large.
here are first formed
lactites of the ordi-
ry conical type. Then
position is confined
ly to one side of the
lactite, the side,
mely, over which the
scending water flows.
rowth takes place then
most wholly in this
posit is, however, also
vater flowing over it.
r, downward at the
t right angles to the
wth of the stalactites
and the group thus
t thrown into folds.
to be the points of
nay be longest some
the surface showing
to those so common
current is compara-
ng period of time the
wing to the fact that
more material than

those at the side. The mass in Shiloh Cave mentioned above and the "Canopy"* in Wyandotte Cave, are excellent illustrations of such formations.

COAN'S CAVE.

The spelling, "Coon's", given by Blatchley† for the name of this cave seems to be incorrect. According to residents of the region the cave derives its name from one of the original owners of the land on which the cave is situated, whose name was Coan.

The entrance to the cave is well-shaped, and is not unlike the

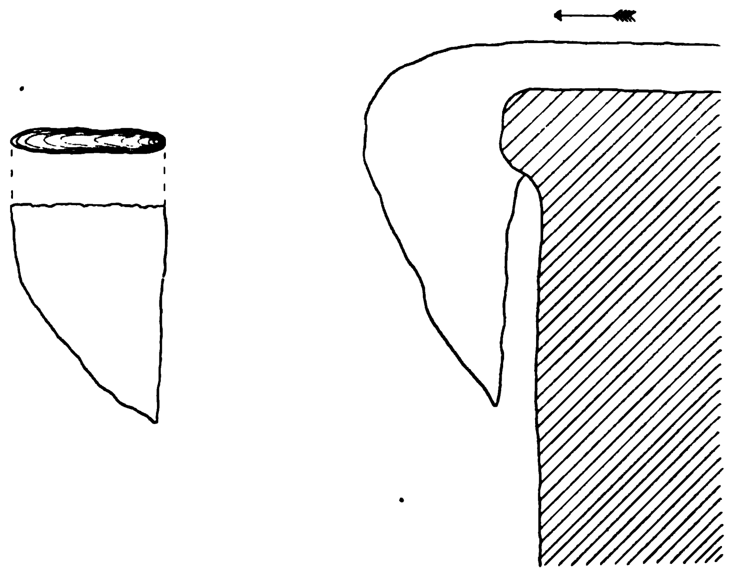


FIG. 8—Diagram illustrating manner and directions of growth of leaf stalactites. The arrow shows the direction of the water current. The cross section at the left shows rings of growth.

descriptions given of cenotes previously referred to. The cavity gradually enlarges toward the bottom. A small surface stream occasionally flows into the cave. The entrance is a good illustration of ingress obtained by following the path of the stream which has formed the cave, in contrast to the entrance to Wyandotte and Mammoth Caves, which are of the nature of openings made by a fallen roof.

*Figured in Report of Indiana Geological Survey for 1896, Pl. X.

†*Op. cit.*, p. 129.

Explanation of Pl. XXXIII.

Strings of crystals obtained from solutions of copper sulphate, lead chloride and nickel-alum, showing increase in size of crystals and amount of deposit toward the bottom of the solutions. A shot used to weight the string appears in the central figure.

The mos
..ently d
The calc
..e unit rh
..m (101
..ght angl
..., and n
.. from qu
..ceable t

Fig. 9—
..crysta
.. XXX
..pper su
..salts p
principl
..dwig
..n to
..ze of t
.. less t
In t
..ary typ
..escribe
..oth de
..der o
..gmites
..ill.

*O
†B

The most unique feature of this cave is the pool at its end, excellently described by Blatchley.*

The calcite crystals which line the walls of the pool are made up of the unit rhombohedron r $(10\bar{1}1)$ and the unit prism of the first order m $(10\bar{1}0)$. (Fig. 9.) The crystals have all grown in a direction at right angles to the plane of their attachment. The prism is quite short, and no crystals are doubly terminated. The crystals vary in size from quite minute to those the size of an ordinary acorn. It is noticeable that they increase in size toward the bottom of the pool.

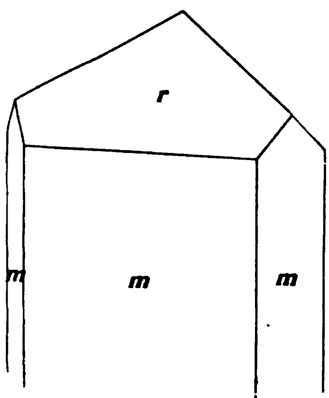


FIG. 9—Calcite, Coan's Cave.

In order to determine whether it was commonly true that crystals increased in size toward the bottom of a solution, with the assistance of Mr. H. W. Nichols, I prepared solutions of a number of salts, placed them in long slender jars and then immersing strings vertically, noted the quantity and size of crystals deposited. In nearly every case the deposit took a marked conical form. The base of the cone and therefore the greatest amount of deposit was at the lowest point in the solution. It was also generally true that the size of the crystals increased toward the bottom. The accompanying plate (Pl. XXXIII), showing strings of crystals obtained from solutions of copper sulphate, lead chloride and nickel-alum, illustrates this. Such results point to a greater concentration of solutions at the bottom, a principle already established with regard to solutions in general by Ludwig and Soret.† It may be worth while, however, to call attention to this illustration of the principle, and to the fact that the size of crystals depends on the degree of concentration of the solution no less than on the time given for their formation.

In this part of the cave stalactites and stalagmites of the ordinary type appear in close association with the crystal deposits just described. The formations have a similar origin in that they are both deposits of carbonate of lime from solution in water. They differ only in the condition that in the making of stalactites and stalagmites the water was moving, while in the making of crystals it was still. If I am correct in this conclusion the converse of the principle

*Op. cit., p. 132.

†Becker, Am. Jour. Sci., Vol. 153, pp. 21-40.

affords a rule perhaps of some value as a guide to the conditions under which banded formations have taken place as compared with those which exhibit distinct crystals. Substances deposited from solution in water which exhibit a banded or layered structure have, according to this rule, been formed by moving waters, while those in the form of distinct crystals have been deposited from waters at rest. Hence, the banded structure so characteristic of mineral veins may be considered proof that the deposit was formed from moving waters while the occasional cavities lined with crystals show points at which the solutions were at rest. Similar conclusions may be drawn regarding the same structures as seen in agates and geodes. It is evident, further, that the conditions in the two cases also differ in the quantity of liquid present and in the rate of deposition. The layered structure is the result of *trickling* waters from which deposition is necessarily rapid, while the distinct crystals were formed from a solution which was present in quantity, and from which deposition was comparatively slow. The applications of these principles to conclusions regarding the origin of veins are obvious. The terms motion and rest are, of course, here to be understood in a purely relative sense, as no body of liquid would be entirely free from internal currents. Further, it is to be granted that all gradations may be traced between a banded structure and distinct crystals. In a broad sense, however, the rule stated in these terms may be of some value.